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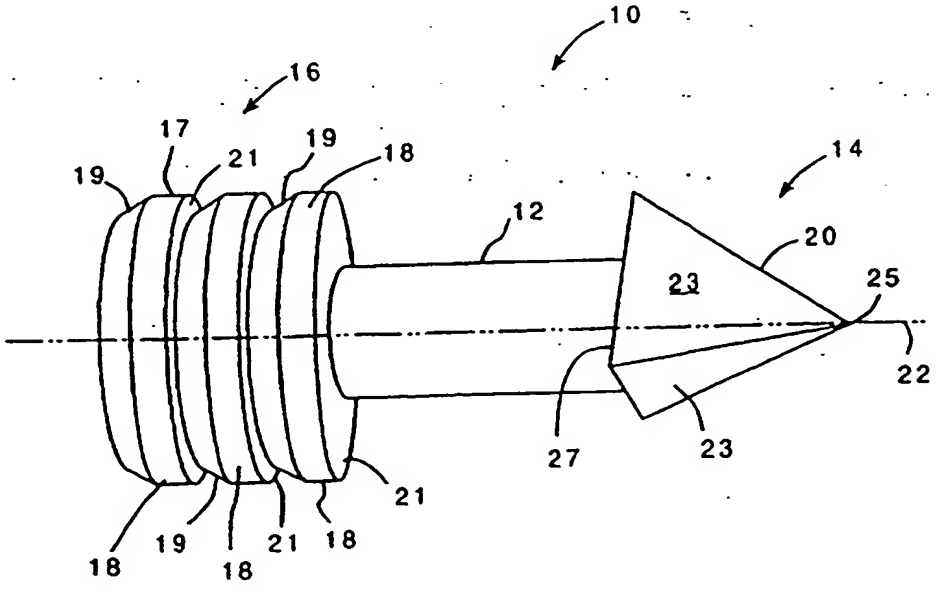

(57) Abstract

A tissue attachment device (10) comprises a body (12) disposed along an axis (22) between a plurality of ends (14, 16), with each of the ends being configured to be inserted into tissue along the axis and to anchor itself within the tissue. One end of the device can be inserted into, e.g., bone, so that the opposite end of the device protrudes from the bone. Softer tissue (e.g., a ligament, a tendon, or cartilage) is pressed onto the exposed end of the device which becomes anchored within the soft tissue, thereby securing the softer tissue in place against the bone. Because the exposed end of the device is anchored within the softer tissue, the articular surface of the softer tissue (i.e., the surface opposite to the surface which is pressed against the bone over the exposed end of the device) is undisturbed. Accordingly, patient pain and healing time are significantly reduced.

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TISSUE ANCHOR

This invention relates to anchoring tissue.

One traditional way of anchoring tissue in place is with suture. For example, during arthroscopic surgery on the knee, shoulder, etc., a suture-carrying anchor is installed into bone, and the suture is threaded through the tissue (such as a ligament, tendon, or cartilage) which is to be attached to the bone. The suture emerges from the articular surface of the tissue (e.g., the surface exposed to the joint) and is knotted or otherwise secured to fasten the tissue in place. Alternatively, the tissue may be staked in place by driving a pin through tissue from its articular surface and into the bone.

This invention features attaching tissue in place with a device which does not disturb the articular surface of the tissue being attached.

In accordance with one general aspect of the invention, the tissue attachment device comprises a body disposed along an axis between a plurality of ends, and each of the ends is configured to be inserted into tissue along the axis and to anchor itself within the tissue.

Preferred embodiments may include the following features.

Each end is configured to anchor itself within the tissue by frictionally engaging a portion of the tissue that lies solely beneath a surface of the tissue. One or both ends of the device can be inserted into tissue through the tissue surface.

In one embodiment, a first end of the device has an anchoring configuration selected to be anchored within bone, and a second end of the device has an anchoring configuration selected to be anchored within softer tissue. This embodiment is particularly useful in anchoring soft tissue such as a ligament, tendon, or cartilage to the bone.

In use, the first end of the device may be inserted into the bone (either into a preformed hole or through the bone surface), and the second end of the device protrudes from the bone. The softer tissue is pressed onto the second end of the device, which becomes anchored within the soft tissue, thereby securing the softer tissue in place against the bone.

Because the second end of the device is anchored within the softer tissue, the articular surface of the softer tissue (i.e., the surface opposite to the surface which is pressed against the bone over the second end of the device) is undisturbed. The attachment thus does not create a site on the articular surface (such as the protrusion of suture or an anchoring pin) where a defect may reform. Moreover, nothing which may interfere with the operation of the joint is left protruding from the articular surface. Accordingly, patient pain and healing times are significantly reduced.

The ends of the device may have the same or different anchoring configurations. For example, in one embodiment one of the ends includes at least one circumferential rib, while the other end is equipped with a pointed barb. The ribbed end is particularly well-suited for attachment within a pre-drilled bone hole, and the pointed barb easily pierces the softer tissue that is to be anchored in place against the bone.

In an embodiment in which the anchoring configuration of the ends are substantially the same, each end includes a barb. Preferably, each end has a plurality of axially spaced barbs, and the barbs of the two ends are oriented in opposite directions. As a result, each end is easily inserted into tissue in one axial direction and resists pull-out in the opposite axial direction. This configuration is particularly useful in joining two segments of soft tissue (such as two pieces of cartilage) together.

The ends of the device can be of substantially the same size, or not. For example, one end may be enlarged relative to the other to provide a secure fit within, e.g., bone, while the opposite end may be relatively small to anchor itself within, e.g., a small-sized tissue plug that is to be attached to the bone. Indeed, one particularly useful application of the attachment device (whether the same or different-sized ends are used) is to secure disk-shaped cartilage grafts to bone to repair cartilage defects.

A shoulder may be disposed on the body between the ends. The shoulder aids the surgeon in installing the device at the proper depth in the base tissue (e.g., the bone). This helps assure that the exposed end of the device does not protrude too little (which might hamper anchoring effectiveness) or too far (which may cause the end to break the articular surface of the attached tissue).

The body preferably comprises biodegradable material such as polyglycolic acid, polylactic acid, polyglycolide-co-lactide (VICRYL®, Ethicon Inc.), poly (p-dioxanone (PDS®, Ethicon), polyglycolide-co-trimethylene carbonate (MAXON®), Davis and Geck) and polytrimethylene carbonate (Boehringer Ingelheim).

Non-biodegradable materials may also be used.

Other features and advantages will become apparent from the following detailed description, and from the claims.

Fig. 1 shows a tissue attachment device.

Fig. 2 illustrates the use of the tissue attachment device of Fig. 1.

Fig. 3 shows another configuration of the tissue attachment device of Fig. 1.

Fig. 4 illustrates the use of the tissue attachment device of Fig. 3.

Referring to Fig. 1, a tack-shaped tissue attachment device 10 includes a cylindrical body 12 disposed along an axis 22 between a proximal end 14 and a distal end 16. As discussed below, each end 14, 16 is configured to be inserted into tissue along axis 22 and to anchor itself within the tissue. Device 10 is made from a bioabsorbable material such as PGA (polyglycolic acid).

Distal end 16 includes three axially spaced circumferential ribs 18. The sides 17 of ribs 18 are parallel to axis 22 and define a cylindrical shape. The distal surface 19 of each rib 18 is inclined with respect to axis 22 (e.g., at between 10 degrees and 80 degrees, and preferably at about 30 degrees). In contrast, the proximal surface 21 of each rib 18 is oriented perpendicularly to axis 22. (Alternatively, surfaces 21 can be back-cut by a few degrees in the same direction as distal surfaces 19 so as to be oblique to axis 22.)

Proximal end 14 is equipped with a pointed barb 20. The surfaces 23 of barb define a pyramidal shape and converge at a sharp proximal tip 25. The distal surface 27 of barb 20 (i.e., the

base of the pyramid) is flat and is oriented perpendicularly to axis 22. (As an alternative, distal surface 27 can be back-cut at an oblique angle to axis 22.)

Referring also to Fig. 2, the use of device 10 to attach tissue 30 (e.g., a cartilage plug) to tissue 32 (e.g., bone) will be described. Preliminarily, note that cartilage plug 30 will serve as a graft to repair defective or injured cartilage, which previously been removed. The adjacent cartilage 31 is either healthy or includes other cartilage plugs that have been attached to bone 32.

First, ribbed distal end 16 of device 10 is inserted into a preformed hole 34 in bone 32 along axis 22 (i.e., in the direction of arrow 36). Bone hole 34 should be slightly smaller than the diameter of ribs 18 to ensure that end 16 fits tightly therein. Inclined distal edges 19 of ribs 18 facilitate insertion. Thereafter, flat (or back-cut) edges 21 frictionally engage bone tissue at the sides 35 of hole 34 to resist pull out (in the direction of arrow 38).

With distal end 16 anchored within bone 32, barb 20 protrudes from bone 32 into the defective area. Note that point 25 is positioned below the articular surface 40 of the adjacent cartilage 31 (and hence below the articular surface of the joint). Cartilage plug 30 is then pressed onto barb 20 along device axis 22 (i.e., in the direction of arrow 36) and is urged against the surface of bone 32. Point 25 enters the lower surface 42 of plug 30, and barb 20 easily passes into interior 44 as plug 30 is inserted. Thereafter, barb distal end 27 frictionally engages plug interior 44 to resist pull out (i.e., in the direction of arrow 38).

Note that because barb 20 is anchored entirely within plug interior 44, the articular surface 46 of cartilage plug 30 is not pierced or otherwise disturbed, and nothing protrudes from articular surface 46 into the joint space. Thus, the repair is made with minimal patient discomfort, decreased healing time, and reduced risk of defects subsequently reforming.

Other embodiments are within the scope of the claims.

For example, rather than having different anchoring configurations (as is the case with device 10), the anchoring configuration of the ends may be substantially the same.

Fig. 3 shows an example of a tissue attachment device in which the anchoring ends of the device are symmetrical. Device 50 includes a cylindrical body 52 disposed along an axis 53 between a proximal end 54 and a distal end 56. As with device 10, ends 54, 56 are each configured to be inserted into tissue along axis 53 and to anchor itself within the tissue. An enlarged shoulder 55 is formed on body 52 mid-way between ends 54, 56 for purposed to be discussed.

Ends 54, 53 are respectively equipped with a set of axially spaced barbs 58, 60. Barbs 58 are oriented in an opposite direction along axis 53 from barbs 60. For example, each barb 58 has a proximal surface 59 which is inclined with respect to axis 53 so that barbs 58 can be inserted into tissue in the direction of arrow 62. The distal surface 61 of each barb 58 is back-cut with respect to axis 53 to resist movement of device 50 in a direction opposite to arrow 62 after device 50 has been inserted into the tissue.

Barbs 60 are the mirror images of barbs 58. Thus, the distal surface 63 of each barb 60 is inclined with respect to axis 53 to permit end 56 to be inserted into tissue in the direction of arrow 66. In contrast, the proximal surface 65 of each is back-cut with respect to axis 53 to resist subsequent pull-out of end 56 from the tissue.

Fig. 4 shows attachment device 50 used to join together two segments of soft tissue (e.g., cartilage) 72, 74 (if required by the size of segments 72, 74, other attachment devices, not shown) may be used as well). Distal end 56 is inserted into cartilage 72 through surface 76 in the direction of axis 53. Shoulder 55 limits the depth to which end 56 is inserted to ensure that proximal end 54 protrudes from cartilage 72 by the proper amount. Barbs 60, and in particular surfaces 65 thereof, frictionally engage portions of cartilage 72 to anchor end 56 within the cartilage and resist pull-out.

Cartilage 74 is then pressed onto proximal end 54 along device axis 53. Barbs 58 enter tissue 74 through lower surface 77 and frictionally anchor themselves within interior 78. As with device 10, proximal end 54 lies completely within the attached tissue and does not pierce or otherwise disturb the articular surface 80 of cartilage 74.

Still other embodiments are possible. For example, while the ends 12, 14 and 54, 56 of the respective devices have been illustrated to be of the same size, either end may be enlarged relative to the other. Other materials, such as nonbiodegradable plastics and metal, may be used.

The tissue attachment device can be used to secure any suitable kind of grafts, such as alografts, autografts, and xenografts.

The ends of devices 10, 50 can have other anchoring configurations. For example, different numbers of ribs 18 (Fig. 1) or barbs 58, 60 (Fig. 3) may be used. Barbs may be used in place of pyramidal barb 20 in device 10. Likewise, ribbed end 16 can be substituted for, e.g., barbs 56 of device 50.

CLAIMS

1. A tissue attachment device, comprising a body disposed along an axis between a plurality of ends each of which is configured to be inserted into tissue along said axis and to anchor itself within the tissue.

2. The device of claim 1 wherein each of said ends is configured to anchor itself within the tissue by frictionally engaging a portion of the tissue.

3. The device of claim 2 wherein the portion of the tissue is disposed solely beneath a surface of the tissue.

4. The device of claim 1 wherein one of said ends is further configured to be inserted into the tissue through a surface thereof.

5. The device of claim 1 wherein each of said ends is further configured to be inserted into the tissue through a surface thereof.

6. The device of claim 1 wherein a first one of said ends has an anchoring configuration selected to be anchored within bone, and a second one of said ends has an anchoring configuration selected to be anchored within softer tissue.

7. The device of claim 1 wherein said plurality of ends have different anchoring configurations.

8. The device of claim 7 wherein a first one of said ends includes at least one circumferential rib, and a second one of said ends includes a pointed barb.

9. The device of claim 1 wherein said plurality of ends have substantially the same anchoring configuration.

10. The device of claim 9 wherein said ends each include a barb.

11. The device of claim 10 wherein said barbs of said ends are oriented in opposite directions.

12. The device of claim 11 wherein each one of said ends includes a plurality of axially spaced barbs, said barbs of a first one of said ends and said barbs of a second one of said ends being oriented in opposite directions.

13. The device of claim 1 wherein said ends are substantially the same size.

14. The device of claim 1 further comprising a shoulder disposed on said body between said ends.

15. The device of claim 1 wherein said body comprises biodegradable material.

16. A tissue attachment device comprising

a body disposed along an axis between a plurality of ends each of which is configured to be inserted into tissue along said axis and to anchor itself within the tissue,

a first one of said ends including a pointed barb, and

a second one of said ends having a plurality of axially spaced circumferential ribs.

17. A tissue attachment device comprising

a body disposed along an axis between a plurality of ends each of which is configured to be inserted into tissue along said axis and to anchor itself within the tissue, each one of said ends including a plurality of axially spaced barbs, said barbs of a first one of said ends and said barbs of a second one of said ends being oriented in opposite directions.

18. A method of attaching a first tissue to a second tissue, comprising

mounting a tissue attachment device to the second tissue such that an end of said device is exposed, and

pressing the first tissue onto said end of said device to cause said end to anchor itself within the first tissue.

19. The method of claim 18 further comprising performing said mounting and pressing steps so that said end of said device does not protrude through said first tissue.

20. The method of claim 18 wherein said mounting step includes inserting a second end of said device into the second tissue through a surface thereof.

21. The method of claim 18 wherein said mounting step includes inserting a second end of said device into an opening in the second tissue.

22. The tissue attachment device substantially as described herein with reference to the accompanying drawings.

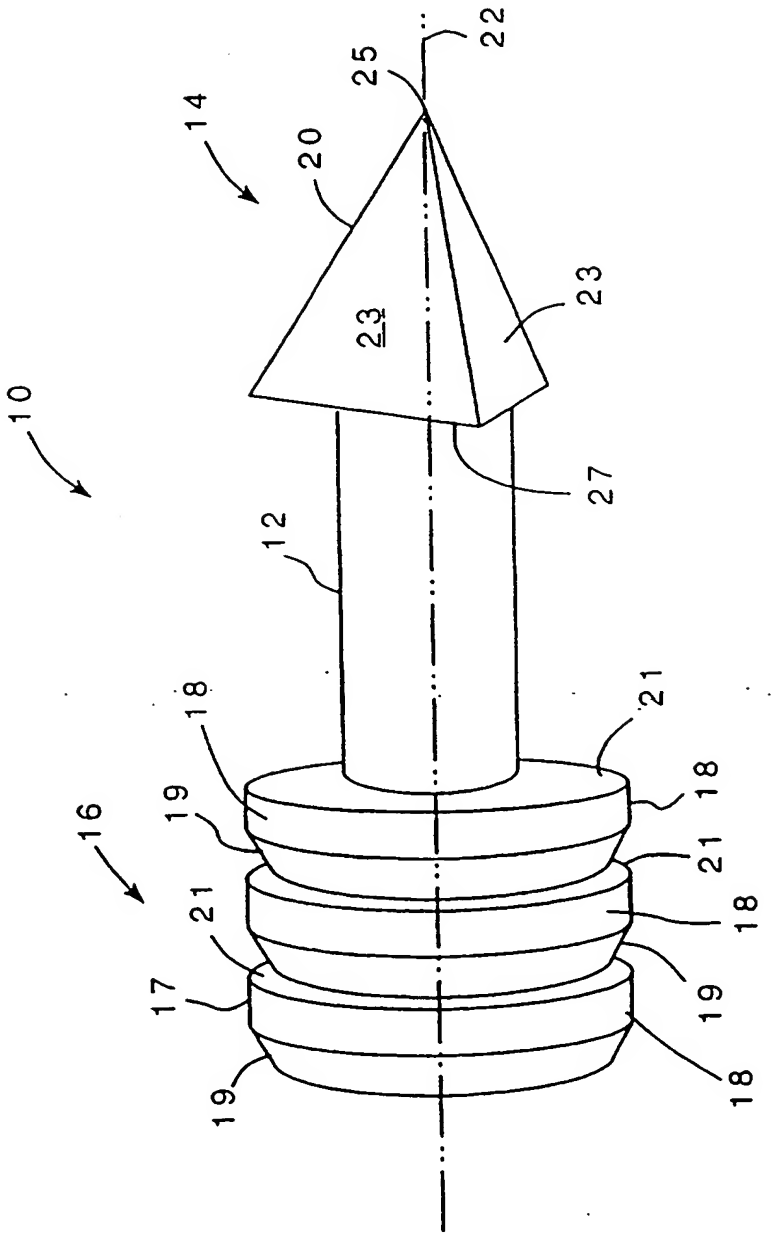
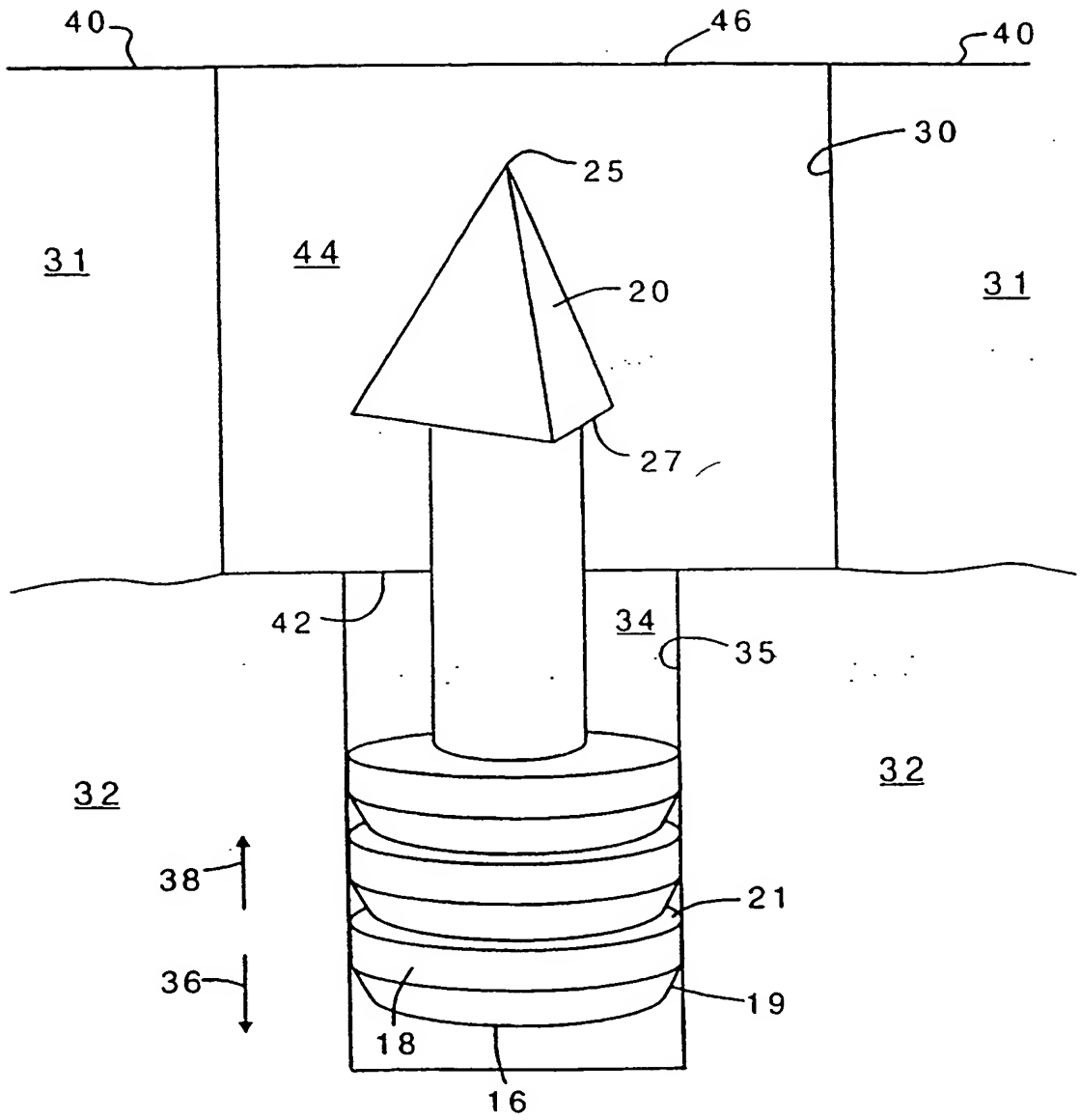


FIG. 1

FIG. 2



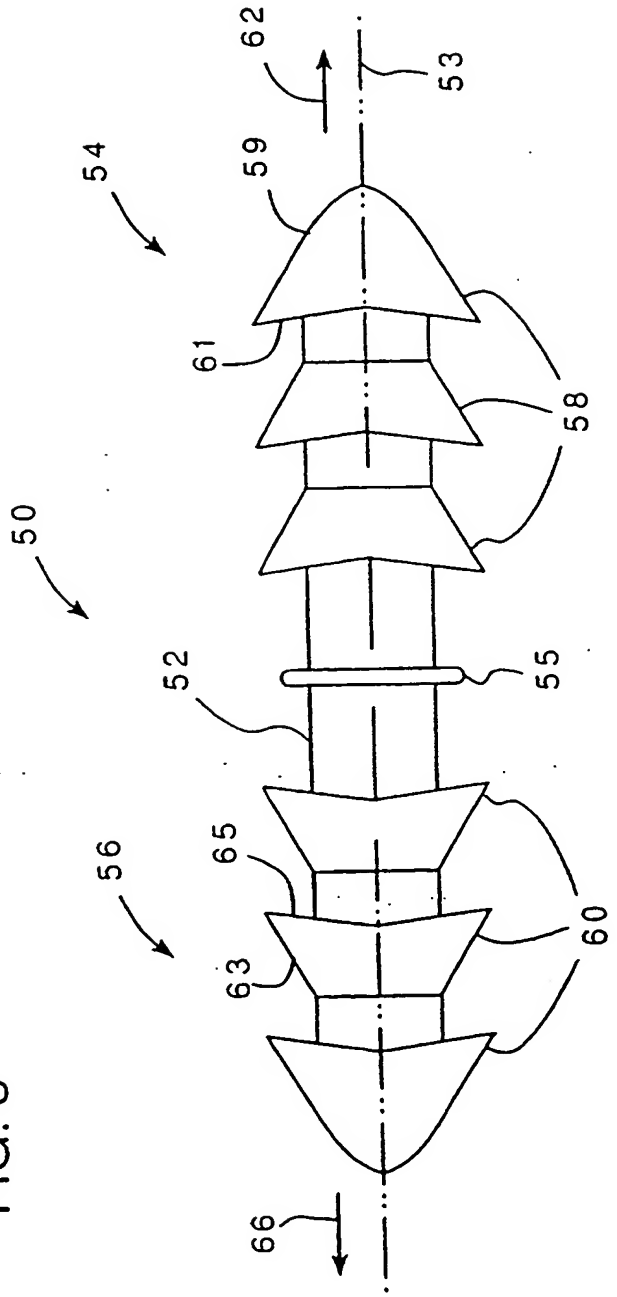
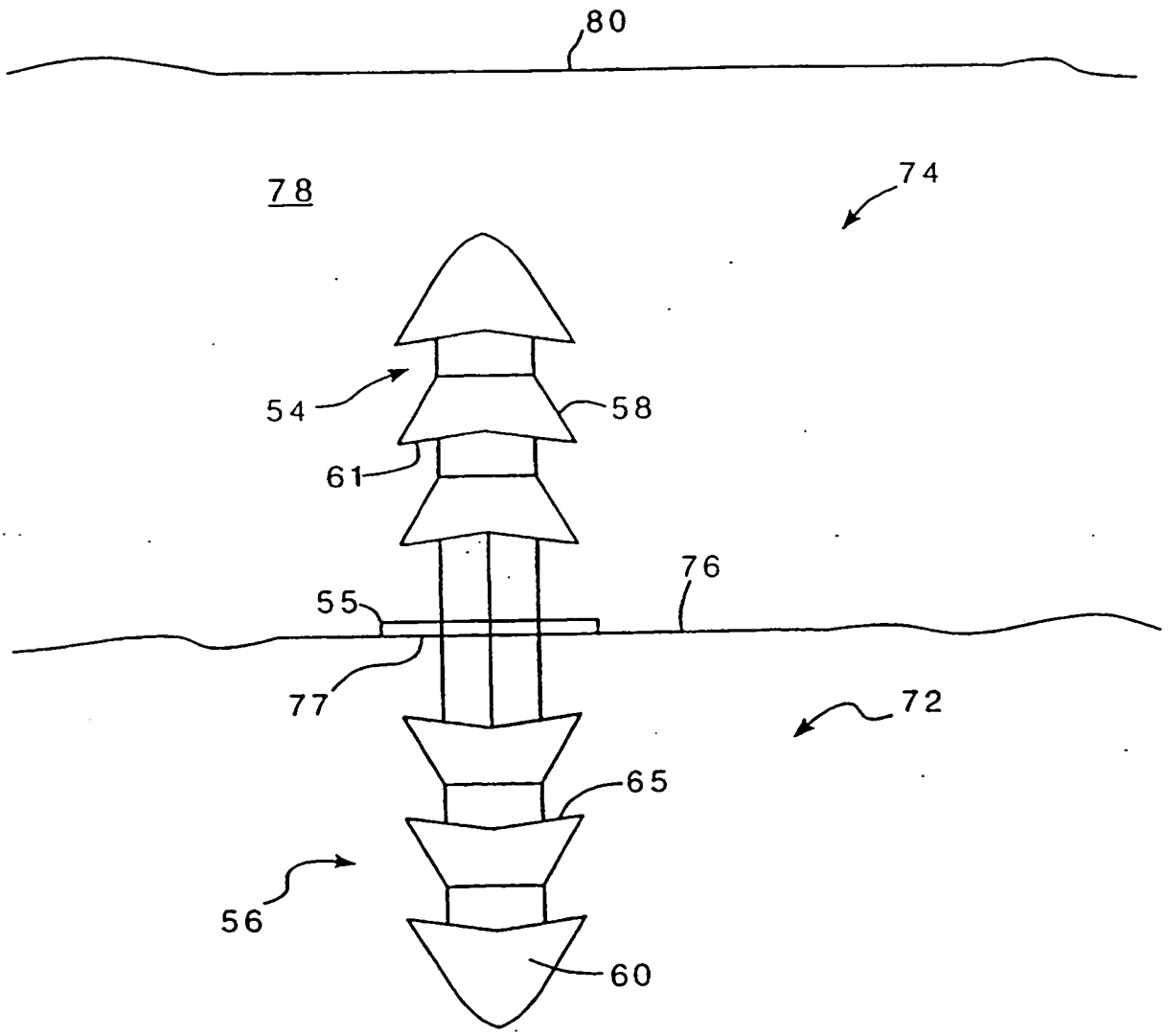


FIG. 3

FIG. 4



A. CLASSIFICATION OF SUBJECT MATTER

IPC(6) : A61B 17/58

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According to International Patent Classification (IPC) or to both national classification and IPC

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Minimum documentation searched (classification system followed by classification symbols)

U.S. : 606/72, 73, 213, 219, 220, 232

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5,417,692 A (GOBLE et al.) 23 May, 1995, entire document.	1-22

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

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